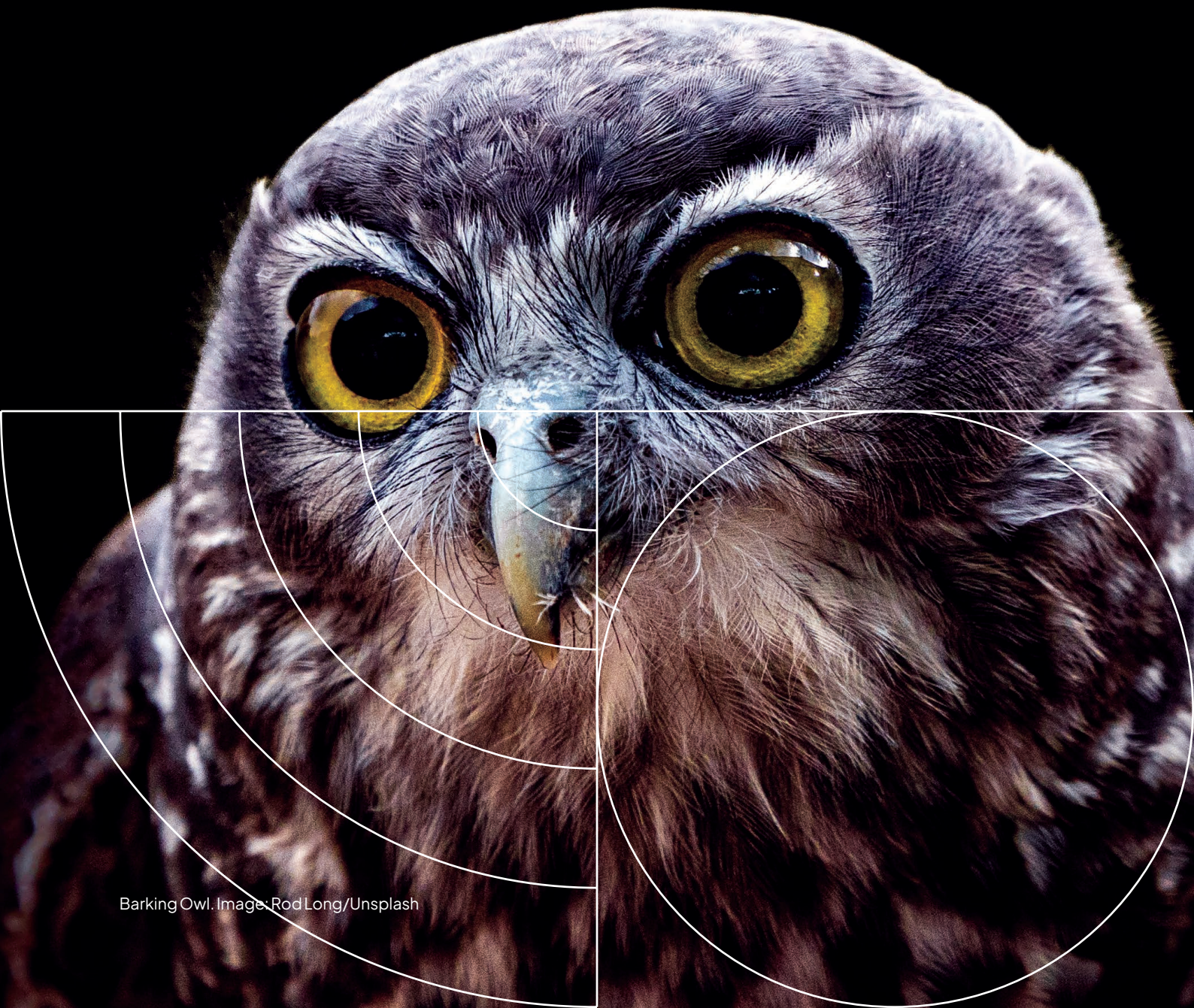
Biodiversity Council

Helping wildlife through biodiversity sensitive lighting:

The effects of light pollution on Australian wildlife



Barking Owl. Image: Rod Long/Unsplash

Further information

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Biodiversity Council

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In brief

The Australian Government has launched a campaign asking people to switch off light pollution to help wildlife. So what does the science say? Does it stack up and should people get involved?

We reviewed research from Australia and around the world on the impacts of artificial light at night on terrestrial vertebrate wildlife, which includes mammals, amphibians, birds and reptiles.

Artificial light at night includes both direct light and sky glow and is also called light pollution. Hereafter we just use the term 'artificial light' to refer to this.

We found that many studies have documented strong negative impacts from artificial light on a wide range of animal species. It can jeopardise the health and survival of individuals, the persistence of populations, and could have significant flow on effects to ecosystems.

This report summarises these research findings, looks at which species are being impacted, makes recommendations on how to minimise harmful impacts on nature, and provides further sources of information.

Artificial light also has major impacts on invertebrates, but that is outside the scope of this research summary.

Like other types of pollution, light pollution is cumulative which is how lots of small night light sources in urban areas combine to create sky glow, which has a wide range of negative impacts on wildlife.

Image: Jan Huber/Unsplash

About the Biodiversity Council

The Biodiversity Council brings together expertise spanning First People's and Western knowledge to help tackle Australia's biodiversity decline and extinction crisis.

Light pollution has a major impact on all six of Australia's marine turtle species. Green turtle image: Randall Ruiz/ Unsplash

Summary of impacts

Our wildlife evolved with natural cycles of light and dark, and in which the moon was the only significant source of night light.

Over the last century as lights have become increasingly efficient and inexpensive we've turned on more and more light. As a result the ambient night light level in our urban areas can be over one million times brighter than what is natural and even backyard spotlights can rival the brightness of the moon to the animals in an area.

All this artificial light has really changed things for the wildlife that we share our world with.

There are a wide variety of impacts on wildlife, which often interact and compound. They include:

- Disorientating species and interfering with navigation
- Making prey species more vulnerable to predators
- Impacting access of food and habitat resources
- Changing circadian rhythms and activity periods
- Increasing stress and reducing health
- Stopping, reducing or changing the timing of reproduction

Reducing energy used for lighting is an important goal in climate action as electricity for lighting accounts for approximately 5% of global greenhouse gas emissions.

However, due to their blue-rich short wavelength, energy-efficient high-brightness light-emitting diodes (LEDs) have been found to have greater impacts on wildlife than other artificial lighting types, so reducing the exposure of wildlife to artificial lighting is becoming more important than ever.

Female seaturtles prefer naturally dark beaches without artificial lighting to lay their eggs. The more artificial lighting affects a beach the more they will avoid it, even if it is otherwise very good nesting habitat.

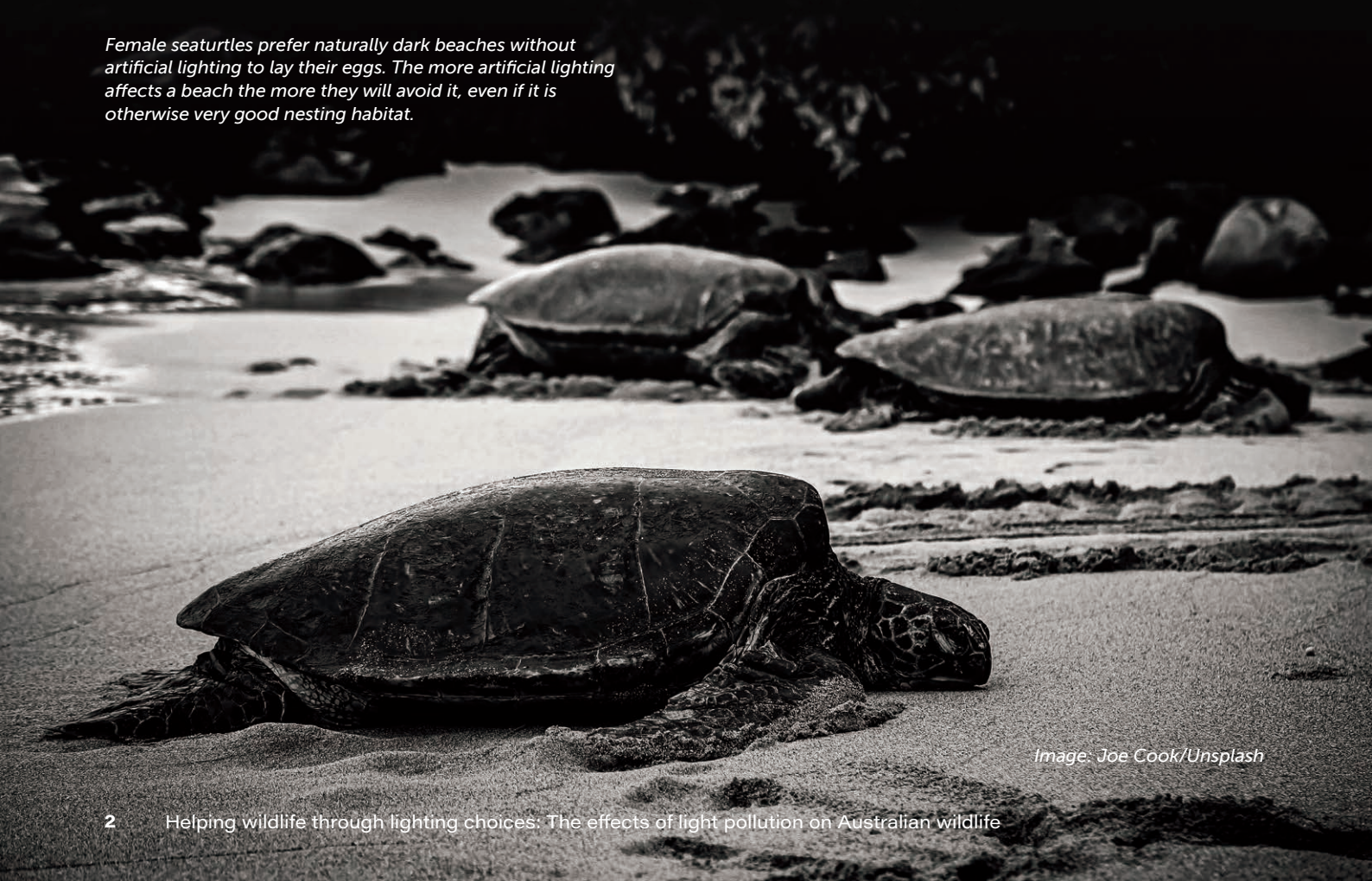
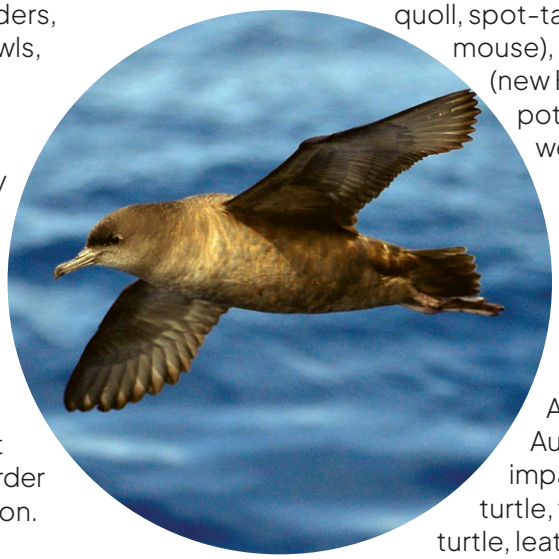


Image: Joe Cook/Unsplash

Which species are being impacted?

A great number of Australian animals are nocturnal, meaning they sleep by day and are active by night. This includes most of our native mammals and frogs and also many birds and reptiles.

Some of the most commonly encountered nocturnal urban wildlife in Australia are possums, bats, bettongs, bandicoots, gliders, antechinus, echidnas, koalas, owls, tawny frogmouths, bush stone curlew, migratory birds, frogs, snakes, moths and geckos. For functioning ecosystems healthy numbers of a wide range of species are important.



Many threatened species occur in urban areas.[1] Other pressures like habitat loss and invasive species may have been a big contributor to their declines but artificial light can make it even harder for threatened species to hang on.

Some of the threatened nocturnally active frogs that occur in urban areas include the Australian lace-lid tree frog, common mistfrog, green and golden bell frog, giant burrowing frog, giant barred frog, stuttering frog, growling grass frog, Wallum sedge frog, and Littlejohn's tree frog.

Threatened bats in urban areas include the bare-rumped sheathtail bat, large-eared horseshoe, large-eared pied bat, south-eastern long-eared bat, spectacled flying-fox and grey-headed flying-fox.

Other nocturnally active threatened mammals include the koala, squirrel glider, eastern barred-bandicoot, southern brown bandicoot, eastern quoll, spot-tail quoll, koala, konoom (smoky mouse), yirkoo (water mouse), pookila (new Holland mouse), long-footed potoroo, western ringtail possum, woylie and Tasmanian devil.

Threatened nocturnally active reptiles in urban areas include the broad-headed snake, while birds include the plains wanderer.

Along our coastlines all six of Australia's sea turtle species are impacted; these are the green turtle, flatback turtle, loggerhead turtle, leatherback turtle, hawksbill turtle and olive ridley turtle, each of which is threatened globally with extinction.

Many of our migratory shorebirds and marine seabirds are also strongly impacted by light pollution, this includes over 40 species of petrels.

Australia's many petrel species are strongly impacted by light pollution. Image: Ed Dunens CC BY 2.0 DEED via Wikimedia

Sometimes mistaken for a rat, the northern brown bandicoot is a nocturnal ground dwelling marsupial that occurs in many urban areas across northern Australia and along the east coast north of the Hawkesbury River. Artificial lighting impacts the bandcoot's vision and makes them more visible to predators.

Image: Mark Gillow CC BY 2.0 DEED via Wikimedia Commons.

Changing predator and prey dynamics and movement

Before artificial lighting, brighter moonlit nights tipped conditions in favour of night hunting species that rely on their eyesight, in Australia that includes invasive predators like feral cats and foxes.[2] So it is not surprising that many studies have found that nocturnal prey animals reduce their activity when lighting is brighter and they are more visible to predators, and even more so when there is less vegetation to hide them.[3]

For example, a study used camera traps at 154 bushland sites in south-eastern Australia to look at how night light levels affect the behaviour of both predators and prey.[3] They found that small native mammals (heath mouse, yellow-footed antechinus, bush rat, southern brown bandicoot, common ringtail possum and common brushtail possum) are more active in darker conditions. On bright moonlit nights these native mammal species reduced their activity by 40–70%.

Artificial lighting can negatively impact animals' movements and access to food and habitat resources. For example, studies of squirrel gliders[4] and sugar gliders[5] found that both species preferred darker areas and minimised time moving and foraging in lit conditions.

Where the landscape has lit and unlit areas, as animals may avoid entering lit areas they can act

A powerful owl brings a possum back to its chicks at a nest in Sydney. Image Chris Charles on Unsplash

Eastern pygmy-possums reduce their activity when there is more night light. Image: Catching the Eye CC BY 2.0 DEED via Flickr

Gould's long-eared bats avoid lit habitat. Image: Department of Environment and Primary Industries CC BY NC 2.0 DEED via Flickr

as a barrier to accessing suitable habitat, and fragment landscapes.

In urban areas where light pollution is widespread, if you see an animal foraging in an area that is artificially lit it does not mean that the animal is happy to be there, in order to eat enough food it may not have a choice.[6] Being in a more brightly lit area is likely to be making the animal feel stressed, especially for prey species, and when this is frequent it can lead to ill health.[7]

Stress is often considered for animals in zoo settings, but has not often been considered in the conservation of wild populations, but it should, especially in stressful urban environments. When an animal feels stressed often it can make it less healthy, less likely to reproduce, or to have less young if it does reproduce[7] which can jeopardise the persistence of animal populations.

Artificial night lighting can disrupt foraging, fat storage, and growth in adult frogs.[8] The patchiness of light levels in areas with artificial lighting, including the movement of car headlights, also makes it harder for frogs' eyes to adjust to light conditions.[8]

Studies of bats overseas have found that captive bats will avoid exploring or eating food in areas that were dimly illuminated, and that wild free-ranging fruit-eating bats were less likely to eat fruit in areas illuminated by street lights than in naturally dark areas.[9]

A study of Gould's long-eared bats in Cumberland State Forest, a 40–ha bushland area in north-west Sydney found that the bats preferred unlit habitat and were less likely to use areas that were exposed to artificial light.[10]

Other studies have shown that artificial lights affect many bats by delaying when they become active in the evening, and altering their flight speed and path.[11] While many bats avoid artificially lit areas, some actively hunt moths that are attracted to street lights; this increases their risk of collisions and can ultimately be unsustainable for the moths with flow on impacts for the bats.[12] [13]

Some reptiles and frogs can also be attracted to the invertebrates that are attracted by artificial light including under street lights, which increases the likelihood of car strikes.[8]

Smaller ground dwelling native animals use dark habitat to avoid being spotted by predators like the invasive European red fox. Image: Phil Plante/Unsplash

Interfering with navigation

The moon and stars were once the only sources of night light and many species evolved to use those light signals for navigation. In some species those natural navigation instincts are being triggered by artificial lights.

Artificial lighting can attract and disorientate migrating birds leading to collisions and more energy used on circling and calling; effects are stronger when lighting is brighter.[14] [15] In the United States 6.8 million birds per year strike illuminated communication towers[16] and hundreds of millions strike buildings. A study in Chicago found that decreasing lighted window area could reduce bird mortality by 60%.[15]

Every extra bit of light pollution matters. Even though New York already has substantial light pollution, a September 11 memorial which shoots high power beams of light into the sky attracts and disorientates hundreds of thousands of birds each year, with birds present in densities 20 times greater than those in the surrounding areas when the memorial lights are illuminated.[14]

Artificial lighting impacts are far more significant at certain times and places of year. For example, near petrel breeding colonies, when the adult seabirds arrive from the northern hemisphere and very critically when the young leave their nesting burrows to start their northward migration.

Burrow-nesting petrel species (including shearwaters and storm-petrels) are nocturnally active at their breeding colonies, and their fledglings (young) depart their nests to start their migration at night. Many studies have documented artificial lights disorientating and attracting fledgling petrels, causing them to be grounded due to exhaustion or collisions.[17] [18] Grounded birds that do not first die from collisions, are at high risk from predation and car strikes.

On Phillip Island, Victoria, a 15 year study documented an average of 591 fledging short-tailed shearwaters per year being grounded by artificial street and car headlights on their first flight and that 39% of those were found dead or dying.[19]

The significance of the light attraction is evident through the large proportion of birds being impacted. For example, the global population estimate of Markham's storm petrels is estimated at 60,000 and in 2017 in Chile 20,000 fledglings died from hitting LED lamp posts that replaced warmer spectrum lights.[20] [21] On Reunion Island a

A short-tailed shearwater emerges from a burrow at a breeding colony on Bruny Island, Tasmania. Young shearwaters leave the nest to start their northward migration under cover of darkness. Large numbers of young shearwaters die through collisions and exhaustion on their first flight if artificial lights are visible.

Image: Tim Cooper CC BY-NC-ND 2.0 DEED via Wikimedia Commons

4 year-study found that 20% of the Endangered Barau petrel fledglings produced each year are lost through attraction to lights on their first flight.[22]

Artificial light typically has the most impact on fledglings in the first few hours after dark, and less impact if there is a full moon.[18] [22]

Even after they reach the ocean fledglings can still be attracted to lights. In 2012, when brightly lit during construction, the Wonthaggi desalination plant attracted and grounded 237 fledgling petrels from breeding colonies at least 15 km away.[19] Many seabirds also collide with brightly lit offshore oil and gas platforms.[23]

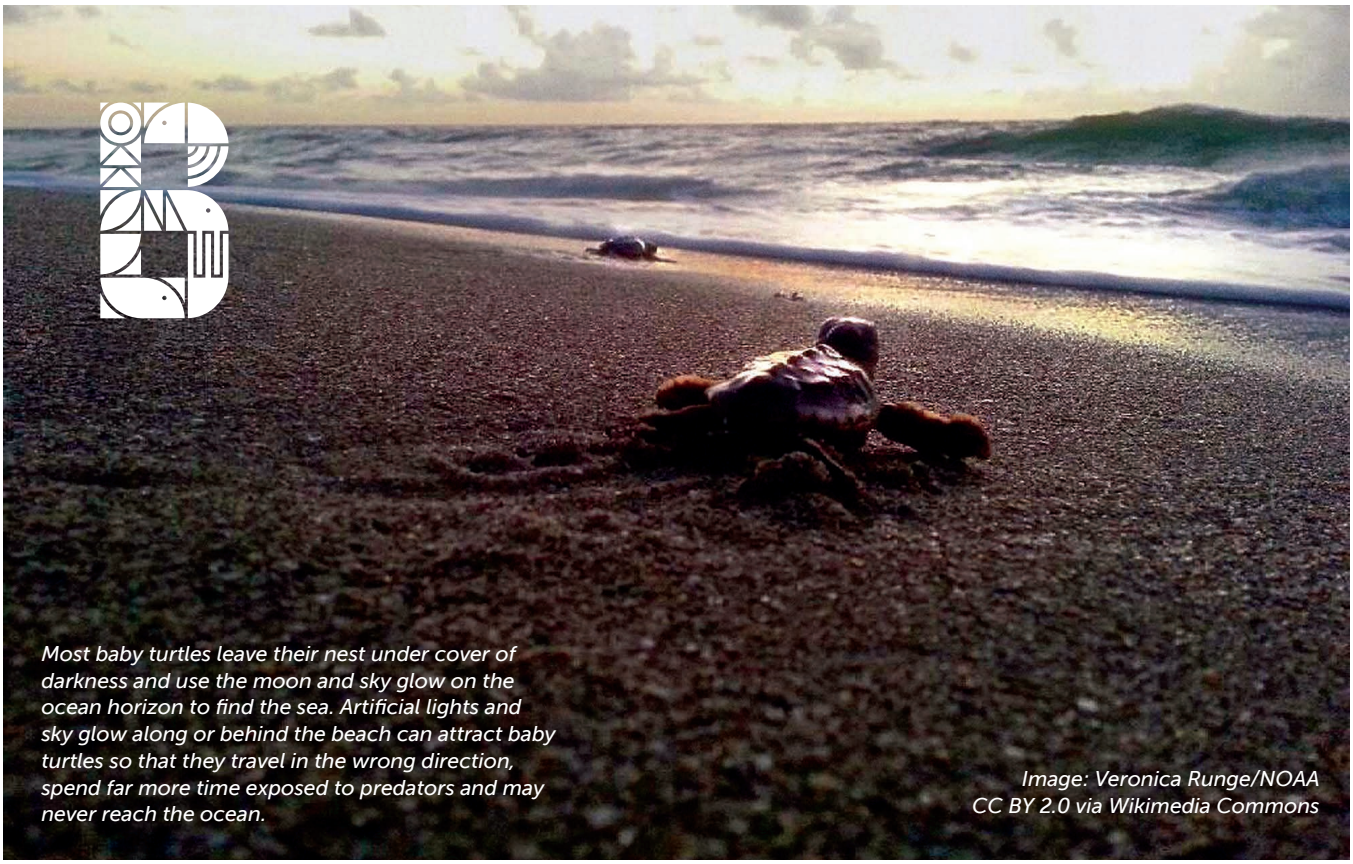
Night time exposure to shorter-wavelengths of blue-violet, or 'cool-white', light from light emitting diodes (LEDs) and metal halide lamps are more problematic for many species. A second study on the short-tailed shearwaters in Victoria found that; one quarter (24%) of fledging short-tailed shearwaters were grounded by high pressure sodium lights but half (47%) were grounded when metal halide lights, which are richer in blue-light, where turned on.[17]

Some species of migrating seabirds are attracted toward artificial lighting and others strongly avoid it. In both cases when birds are migrating it has been shown to prevent birds using higher quality feeding and roosting sites, and to limit the duration of stopovers, all of which could affect survival during the migration.[24]

Extensive research around the world has documented strong negative impacts from artificial light on sea turtles. Although female turtles return close to their birth beach studies have found they will reduce nesting on artificially lit beaches, and that lighting intensity and colour influence how strongly the adult female turtles will avoid the beach. [25] [26]

Turtle hatchlings use moonlight and the glow of the ocean horizon to find the sea. Many studies have shown that direct artificial lights and sky glow along or behind the beach attract baby turtles so that they travel in the wrong direction, spend far more time exposed to predators and may never reach the ocean.[27]

A study on Heron Island found that on moonless nights, even after sea-turtle hatchlings have reached the ocean they can be lured back to shore again by shore-based light pollution.[28] It isn't just lights at the beach that are problematic, any lights that can be seen from the beach, such as a brightly lit house on a hill kilometres away can disorientate young turtles.



Most baby turtles leave their nest under cover of darkness and use the moon and sky glow on the ocean horizon to find the sea. Artificial lights and sky glow along or behind the beach can attract baby turtles so that they travel in the wrong direction, spend far more time exposed to predators and may never reach the ocean.

Image: Veronica Runge/NOAA
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Biological impacts on circadian rhythm and reproduction

Like humans, animals' circadian rhythms, hormones and melatonin levels are all influenced by light and darkness.[29] [30] Artificial lighting can disrupt these internal biological processes which increases stress and reduces immune system function for the animal,[31] much like people feeling poorly and being more susceptible to getting sick when they are sleep deprived.

Exposure to as little as 1 minute of artificial light has been found to disrupt the production of melatonin in some frog species.[8] Sky glow has also been found to affect the colouration of tadpoles, and the age and size at which tadpoles metamorphose into frogs.[8] It slows down frog growth rates and behavioural activity.[32] Frogs exposed to artificial light at night have been documented making less breeding advertisement calls and moving more, both of which could negatively affect breeding.[33] Artificial lighting has also been found to change mate choice in many species of adult frogs and to reduced egg fertilisation by males.[34] Studies of some frog species have found that exposure to constant light causes eye abnormalities.[8]

Studies have also documented impacts from light pollution on day-active bird species. Night sky glow has been found to change calling behaviours at dawn, dusk and at night[35] [36] and to affect bird reproduction. Reproductive impacts include birds reaching reproductive maturity earlier, changing egg laying dates[37] and abnormal and/or delayed eye development in chicks.[38]

Shorter-wavelength blue-rich light such as LEDs have been found to have much greater impacts on circadian rhythm and melatonin levels, in mammals[39] [40] and birds.[41]

Exposure to LED light has been found to cause delayed births in tammar wallabies.[40] [42] Several studies have found increased impacts from LED compared to other lighting types in bats.[11] [12]

Image: The Wallum sedge frog is a threatened species found in swamps and wetlands along the east coast between Hervey Bay and Coffs Harbour - an area with high human population density.

Image: Steve Fox CC0 via Flickr.

The tammar wallaby is a small wallaby native to parts of Western Australia and South Australia. Studies have shown that exposure to LED light causes delayed births in the species.

Image: Oliver C Stringham CC BY 4.0 via Wikimedia Commons

Many species evolved to use the moon for navigation, so when even a single street light can shine more light on to an area than the moon it can cause animals to loose their way. The constant exposure to light can also have a wide range of other negtive health effects.

Image: Yulie Wang/Unsplash

How to reduce our artificial light impacts on wildlife

Australia's native animals need our help. Since Europeans arrived 67 unique Australian animals have become extinct and 563 more have become threatened with extinction. Many species that were once common are now rare and lost from many of their former areas.

Light pollution is not the only problem facing these species, but for some species and in some places it can be the 'straw that breaks the camel's back', and make it that much harder for animals to survive other pressures. For some species light pollution is one of the biggest threats to their survival.

Our urban areas are frequently pretty bright at night, so you may feel that what you do won't make a difference, but the good news is that your actions do make a difference.

Like other types of pollution such as carbon emissions, light pollution adds up. This means that every extra light you can turn off, make dimmer or stop pointing into nature makes a difference. If lots of people get involved the difference that we can make will be enormous.

Here are some simple ways to reduce the impact of your artificial lighting on the wildlife around us.

At home

The easiest and most energy efficient step is to turn off lights that you don't need to have on, especially outdoor lights.

Stop your indoor lighting from shining outdoors at dusk, through the night and at dawn by using curtains that block the light.

Minimise the impact of your outdoor lighting by keeping it turned off when you don't need it. Timers and sensors can help you minimise how long your

When garden plants are uplit it reduces the amount of habitat available for native animals in the area and makes it harder for them to move through the landscape to get all the resources they need. It also adds to the sky glow over towns which has more widespread detrimental impacts on wildlife.

Image: Jaana Dielenberg

lights are on, and avoid lights shining when they are not needed.

Sometimes we need some outdoor lighting to help us do a task safely, minimise light pollution by using low intensity lights and dimmers. Amber and red lights have less impact on wildlife than white, blue and green lights.

Keep your lighting directed down to where you need it and choose lights with shielding that prevents the light shining toward the sky or into nearby vegetation or greenspace reserves.

Our urban areas have already lost a lot of trees, so don't make more trees unavailable through light pollution. Fairy lights and floodlights pointing up into trees might look pretty to us but they are blinding for animals and will prevent many animals from using the tree. Let the animals have use of the tree at night by keeping it dark.

Plant corridors of trees and shrubs to provide more dark habitat for animals that also helps them hide from predators.

At Christmas we can also show our community spirit with day time decorations, and window lights displays instead of covering the house and yard in neon that is stressful for animals.

Along the coast

To help turtles, shrebirds and seabirds, avoid using artificial lights on or visible from beaches. This includes electric lights, fires and flares.

If you have to use a light along the coast at night, aim for low-intensity amber and red lights.

Minimise artificial lighting on the water by doing your boating by day and minimising the number and intensity of lights you use at sea.

When you use lights angle them to where you need them and shield lights and fires to prevent light shining in unnecessary directions.

In the community

Light features can be enjoyable, but as a community we can save those outdoor light features for special occassions and for public places, where lots of people can enjoy them.

Let's leave our gardens, parks and coasts for wildlife by making them naturally dark refuges. (This lets people enjoy the wonder of star gazing too).

You can multiply your positive impacts by talking to your friends about light pollution. Let them know about how light pollution impacts wildlife and how they can reduce their light pollution to help.

Street, sports and commercial lights

Many of the brightest lights belong to road managers, sports stadiums and clubs, restaurants and other businesses. The people who operate these lights can make a big contribution to helping wildlife by minimising their light pollution.

Turning off unnecessary lights and dimming ones that need to stay on makes a big difference. In the

Bright lights on beaches, inclusing fires, often lead to the deaths of baby turtles and seabirds if they are in the area, so avoid them whenever possible. Image: Justin Kauffman/Unsplash

Melbourne Shrine of Remembrance. Light displays are best reserved for public places that can be enjoyed by many. Red and amber lights minimise impacts on wildlife. Image: Jesse/Unsplash

Plants like bottlebrushes and Christmas bells can add a festive feel to gardens. Image: Zeynel Cebeci CC BY SA/Wikimedia Commons

Daytime decorations are a great way to be festive without contributing to light pollution. Image: Jaana Dielenberg

US programs encourage office building managers to turn off and dim their night lighting during peak migration periods, to reduce the number of birds colliding into buildings.

Shielding lights to prevent light shining upward also makes a big difference. In Hawaii, attraction to artificial lighting was causing heavy losses of 3 types of fledging threatened petrels. Shielding the lights of the largest resort to prevent upward light glow reduced mortalities by nearly 40%.[18]

Managers of commercial and public lighting near the coast can also find out if there are nesting areas for seabirds or turtles nearby, and take extra care to minimise artificial lights at critical times such as when young are leaving their nests for the first time. There is no one time that this happens for all species. Australia's petrels each have a distinct breeding season, but the timing of each species varies so widely that there are petrels nesting at some location in Australia throughout the year. Turtles are a bit more predictable, with nesting on beaches in Western Australia, the Northern Territory, Queensland and New South Wales occurring from November to April.

Town planning

With all we now know about the impacts of light pollution there are lots of ways that new developments can be designed to minimise the impacts of artificial light on wildlife, and information is generally available from state, territory and local governments. For example, in 2019 the Queensland Government introduced planning scheme guidance to local governments to reduce artificial light from new developments in turtle sensitive areas.[43]

For hundreds of years the Christmas lights tradition was some candles. In recent decades it has become more like the flashing lights of Las Vegas. When lots of people join in it leaves few dark refuges for animals.

Image: Agnostic Preachers Kid CC BY SA 4.0 via Wikimedia Commons

The squirel glider is one of many species that will benefit from reduced light pollution. Most of Australia's mammals and frogs are noctural, as are many of our birds and reptiles.

Image: David Clode/Unsplash

More information

Other good sources of information on how to minimise light pollution are the International Dark-Sky Association, and the Australian Government's 'Let's switch off light pollution together!' websites.

Find more details on any of the research listed in this report by checking our References section on p14.

Trees provide vital habitat for wildlife, but when they are lit like this few animals can use them. Image: Mick Haupt/Unsplash

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Biodiversity Council

The Biodiversity Council brings together leading experts including Indigenous Knowledge holders to promote evidence-based solutions to Australia's biodiversity crisis. It was founded by 11 universities: The University of Melbourne, The University of Western Australia, The Australian National University, The University of Adelaide, The University of Sydney, The University of Queensland, Deakin University, The University of Canberra, Monash University, Macquarie University, and The University of New South Wales. It is host by The University of Melbourne. It receives support from The Ian Potter Foundation, The Ross Trust, Trawalla Foundation, The Rendere Trust, Isaacson Davis Foundation, Coniston Charitable Trust and Angela Whitbread.

Image: The spotted-tailed quoll is a native nocturnal predator found in Queensland, New South Wales, Victoria and Tasmania. Numbers of this animal have greatly reduced since European arrival but it is still found near many urban areas. Image: Daniel Pelaez/Unsplash